Designation: C 1482 – 00ε1

Standard Specification for Polyimide Flexible Cellular Thermal and Sound Absorbing Insulation[1]

This standard is issued under the fixed designation C 1482; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—The title of Table A4.3 was editorially revised in September 2001.

1. Scope

1.1 This specification covers the composition and physical properties of lightweight, flexible open-cell polyimide foam insulation intended for use as thermal and sound-absorbing insulation for temperatures from -328 up to +572° F (-200 and +300° C) in commercial and industrial environments.

1.1.1 Annex A1 includes faced polyimide foam as specified by the U.S. Navy for marine applications.

1.1.2 This standard is designed as a material specification and not a design document. Physical property requirements vary by application and temperature. No single test is adequate for estimating either the minimum or maximum use temperature of polyimide foam under all possible conditions. Consult the manufacturer for specific recommendations and physical properties for specific applications.

1.1.3 The use of an appropriate vapor retarder is required in all applications where condensation could occur and cause a decrease in thermal performance or affect other system properties.

1.2 The values stated in inch-pound units are to be regarded as the standard. The System International equivalents of the inch-pound units are given in parentheses for information only and may be approximate.

1.3 *This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.*

NOTE 1—The subject matter of this material specification is not covered by any other ASTM specification. There is no known ISO standard covering the subject of this standard.

2. Referenced Documents

2.1 *ASTM Standards:*

C 165 Test Method for Measuring Compressive Properties of Thermal insulations[2]

C 168 Terminology Relating to Thermal Insulating Materials[2]

C 177 Test Method for Steady-State Heat-Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus[2]

C 302 Test Method for Density and Dimensions of Preformed Pipe-Covering-Type Thermal Insulation[2]

C 335 Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation[2]

C 390 Criteria for Sampling and Acceptance of Preformed Thermal Insulation Lots[2]

C 411 Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation[2]

C 423 Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method[2]

C 447 Practice for Estimating the Maximum Use Temperature of Thermal Insulations[2]

C 518 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus[2]

C 634 Terminology Relating to Environmental Acoustics[2]

C 665 Specification for Mineral-Fiber Blanket Insulation for Light Frame Construction and Manufactured Housing[2]

C 1045 Practice for Calculating Thermal Transmission Properties From Steady-State Heat Flux Measurements[2]

C 1058 Practice for Selecting Temperatures for Evaluating and Reporting Thermal Properties of Thermal Insulation[2]

C 1114 Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus[2]

D 395 Test Method for Rubber Property - Compression Set[3]

D 543 Test Method for Resistance of Plastics to Chemical Reagents[4]

D 638 Test Method for Tensile Properties of Plastics[4]

D 2126 Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging[5]

D 2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-like Combustion of Plastics (Oxygen Index)[5]

[1] This specification is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.22 on Organic and Non-homogenous Inorganic Thermal Insulations.

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[2] *Annual Book of ASTM Standards*, Vol 04.06.

[3] *Annual Book of ASTM Standards*, Vol 09.01.

[4] *Annual Book of ASTM Standards*, Vol 08.01.

[5] *Annual Book of ASTM Standards*, Vol 08.02.

D 3574 Test Methods for Flexible Cellular Materials - Slab, Bonded, and Molded Urethane Foams[6]
D 3675 Test Method for Surface Flammability of Flexible Cellular Materials Using A Radiant Heat Energy Source[6]
E 84 Test Method for Surface Burning Characteristics of Building Materials[7]
E 96 Test Method for Water Vapor Transmission of Materials[2]
E 176 Terminology of Fire Standards[7]
E 662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials[7]
E 795 Practices for Mounting Test Specimens During Sound Absorption Tests[2]
E 800 Guide for Measurement of Gases Present or Generated During Fires[7]
E 1354 Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter[7]

2.2 *U.S. Federal Standards:*

FAR 25.853(a), Appendix F, Part 1, (a) (1) (i) Test Criteria and Procedures for Showing Compliance with Sec. 25.853, or 25.855[8]
MIL-C-20079 Cloth, Glass; Tape, Textile Glass; and Thread, Glass[9]
MIL-A-3316 Adhesive, Fire-Resistant, Thermal Insulation[9]
MIL-PRF-24688A Performance Specification Insulation, Thermal and Acoustic Absorptive[9]
DOD-E-24607 Enamel, Interior, Nonflaming (Dry), Chlorinated Alkyd Resin, Semigloss (Metric)[9]

2.3 *Private Sector Standards:*

Boeing BSS 7239 Test Method for Toxic Gas Generation by Materials on Combustion[10]
TAPPI T 803 Puncture and Stiffness Test of Container Board[11]
TM-232 Vertical Pipe-Chase Test to Determine Flame-Propagation Characteristics of Pipe Covering[12]

3. Terminology

3.1 *Definitions*—Terms used in this specification are defined in Terminology C 168, Terminology C 634, and Terminology E 176. In the case of a conflict, Terminology C 168 shall be the dominant authority.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *flexible cellular product*—a cellular organic polymeric material that will not rupture when a specimen 8 by 1 by 1 in. (200 by 25 by 25 mm) is bent around a 1 in. (25 mm) diameter mandrel at a uniform rate of one lap in 5 sec. at a temperature between 64 and 85°F (18 and 29°C), in accordance with the description of a flexible cellular product (currently Subsection 3.1.3) in Test Methods D 3574.

3.2.2 *slab*—a rectangular section, piece, or sheet of foam that is cut from a bun, or block of foam.

3.2.3 *polyimide foam*—a flexible cellular product in which the bonds formed between monomers during polymerization are imide or amide bonds. The theoretical mole fraction of imide bonds must be greater than the theoretical mole fraction of amide bonds.

4. Classification

4.1 The flexible polyimide cellular insulations of this specification are classified into Types I through VI as listed in Tables 1 and 2(Note 2). Type I is further subdivided into two Grades based on maximum allowable thermal conductivity at 75° F (24° C). . The Types II and III are subdivided into Classes (Note 3).

NOTE 2—Although all types find application in a wide variety of markets, the current primary market for each type is as follows:

Type I—marine and industrial applications.

Type II—Type II is Type I foam faced and used in specific marine applications, as specified for the U.S. Navy in Annex A1.

Type III—Type III is Type I foam pipe shaped and used in specific marine applications, as specified for the U.S. Navy in Annex A1.

Types IV and V—aerospace applications depending on density.

Type VI—applications requiring improved high temperature and fire performance.

NOTE 3—The Type II and Type III designations as well as the subdivision of Types into Classes is to maintain uniformity with existing U.S. Navy nomenclature (Annex A1).

5. Materials and Manufacture

5.1 Polyimide foam shall be manufactured from the appropriate monomers, and necessary compounding ingredients to conform to 3.2.3. This is not intended to imply that foam products made using different materials are equivalent with respect to all physical properties.

6. Physical Properties

6.1 The insulation shall conform to the requirements in Tables 1 and 2 for each type, unless specifically stated otherwise by agreement between the supplier and the purchaser. Tests shall be made in accordance with the methods specified in 11.1-11.20.

6.1.1 *Upper Temperature Limit*—Upper temperature limit shall be determined according to 11.4 at the application's intended maximum use temperature or at a temperature determined by agreement between the purchaser and manufacturer.

6.1.2 *Burning Characteristics*—The uncoated and unfaced foam shall conform to the requirements in Tables 1 and 2 for each type, when tested in accordance with 11.12-11.19, without the use of flame/smoke or heat suppressant barriers or coatings.

6.1.3 *Sound Absorbing Performance*—Unless specifically otherwise agreed to between the supplier and the purchaser, all tests shall be made in accordance with the methods specified in 11.20.

6.2 The values stated in Tables 1 and 2 should not be used as design values. It is the buyer's responsibility to specify

[6] *Annual Book of ASTM Standards*, Vol 09.02.
[7] *Annual Book of ASTM Standards*, Vol 04.07.
[8] Federal Aviation Regulations Part 25 (Airworthiness Standards, Transport Category Aircraft, and Section 25.853. Procedure in appendix F, Part I, (a) (1) (i) and (ii). Available from Superintendent of Documents, U.S. Government Printing Office P.O. Box 371954, Pittsburgh, PA 15250-7954.
[9] Available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.
[10] Available from Boeing Commercial Airplane Group, Material Division, P.O. Box 3707, Seattle, WA 98124-2207.
[11] Available from the Technical Association of the Pulp and Paper Industry, P.O. Box 105113, Atlanta GA 30348.
[12] Available from Armstrong World Industries, Inc., Research and Development, P.O. Box 3511, Lancaster, PA 17604.

TABLE 1 Polymide Foam Classification (inch-pound)

	TYPE I Grade 1	TYPE I Grade 2	TYPE IV	TYPE V	TYPE VI
Density, max, lb/ft^3	0.48	0.48	0.37	0.55	0.50
Maximum Apparent Thermal Conductivity Btu-in./h ft^2–°F					
–238° F	0.14	0.14	0.14	0.14	0.14
–58° F	0.23	0.22	0.23	0.23	0.23
75° F	0.32	0.29	0.34	0.30	0.34
212° F	0.51	0.47	0.54	0.47	0.50
356° F	0.74	0.70	0.81	0.70	0.74
572° F	NA[A]	NA[A]	NA[A]	NA[A]	1.15
Upper Temperature Limit – test temperature for C 411, °F	400	400	400	400	572
High Temperature Stability – % of initial tensile strength retained after 336 hours in air oven at 400° F, min, %	60	60	NA[A]	NA[A]	NA[A]
High Temperature Stability – % of initial tensile strength retained after 336 hours in air oven at 572° F, min, %	NA[A]	NA[A]	NA[A]	NA[A]	70
Tensile Strength, min, lb/in.^{2}	8.5	8.5	2.8	8.5	3.9
Compressive Strength, min, lb/in.^{2} at 25% deflection	0.5	0.5	NA[A]	NA[A]	0.5
50% Compression Deflection, min, lb/in^2	1.2	1.2	NA[A]	NA[A]	NA[A]
Compression Set, max, %	NA[A]	NA[A]	40	40	NA[A]
Steam Aging					
Change in Tensile Strength, max, %	25	25	NA[A]	NA[A]	25
Dimensional and weight changes, max, %	10	10	NA[A]	NA[A]	10
Corrosiveness	pass	pass	pass	pass	pass
Chemical Resistance	pass	pass	pass	pass	pass
Surface Burning Characteristics, 2 in. thickness[B]					
Flame Spread Index, max	10	10	15	15	10
Smoke Development, Index, max	15	15	20	20	15
Radiant Panel Surface Flammability, Flame Spread Index, max[B]	5	5	5	5	2
Vertical Burn[B,C]					
Burn Length, max, in.	NA[A]	NA[A]	2	2.4	NA[A]
After Flame Time, max, sec	NA[A]	NA[A]	1	1	NA[A]
Total heat release (2 min), max, Btu/ft^2[B]	79	79	NA[A]	NA[A]	NA[A]
Maximum heat release rate, max, Btu/min-ft^2[B]	106	106	NA[A]	NA[A]	NA[A]
Specific Optical Smoke Density, D_m, max[B]					
non-flaming mode	5	5	5	5	5
flaming mode	10	10	10	10	5
Total Hydrogen Halide (HCl, HBr, and HF) Gases in Smoke, Flaming Exposure, max, ppm (Above background for empty chamber)[B]	10	10	10	10	10
Toxic Gas Generation: max, ppm[B]					
CO	300	300	300	300	300
HCN	5	5	5	5	5
HF	5	5	5	5	5
HCl	10	10	10	10	10
HBr	5	5	5	5	5
SO2	5	5	5	5	5
NOx	10	10	10	10	10
Acoustical Absorption Coefficient 2 in. thickness, min Noise Reduction Coefficient (NRC)	0.75	0.70	0.75	0.85	0.70

[A] NA = not applicable

[B] This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk under actual fire conditions.

[C] The material shall not melt, drip, or flow when tested as required.

design requirements and obtain supporting documentation from the material supplier.

7. Workmanship and Appearance

7.1 The slab offered as saleable material shall be free of foreign materials and defects that will adversely affect its performance in service.

7.2 *Voids and Surface Damage*—Surface damage due to handling, and voids that are between 0.24 in. (6 mm) and 1.4 in. (35 mm) in diameter, and extend through the entire slab, may be repaired by gluing, plugging, or cutting and splicing. Voids greater than 1.4 in. (35 mm) in diameter shall be cause for rejection of the affected material. Plugging may be achieved using compression fit or by using adhesives. Adhesives used for repair shall not affect the overall smoke, fire, or acoustic performance required for the material in this specification. Material used for repairs shall be of the same composition and quality as undamaged material. The acceptance of type and amount of repair shall be as agreed upon by the supplier and the user.

8. Sampling

8.1 *Sampling*—The insulation shall be sampled in accordance with Criteria C 390. Otherwise, specific provisions for sampling shall be as agreed upon between the user and the supplier.

8.2 *Specimen*—Specimens of dimensions 12 by 12 by 1 in. (300 by 300 by 25 mm) are sufficient for purposes of acceptance inspection of samples of qualified polyimide foam insulation.

9. Qualification Requirements

9.1 The following requirements are generally employed for initial material or product qualification:

TABLE 2 Polymide Foam Classification (SI units)

	TYPE I Grade 1	TYPE I Grade 2	TYPE IV	TYPE V	TYPE VI
Density, max, kg/m^3	7.7	7.7	5.9	8.8	8.0
Maximum Apparent Thermal Conductivity W/m-K					
–150° C	0.020	0.020	0.020	0.020	0.020
–50° C	0.033	0.032	0.033	0.033	0.033
24° C	0.046	0.042	0.049	0.043	0.049
100° C	0.074	0.068	0.078	0.068	0.072
180° C	0.107	0.101	0.117	0.101	0.107
300° C	NA[A]	NA[A]	NA[A]	NA[A]	0.166
Upper Temperature Limit – test temperature for C 411, °C	204	204	204	204	300
High Temperature Stability – % of initial tensile strength retained after 336 hours in air oven at 204° C, min, %	60	60	NA[A]	NA[A]	NA[A]
High Temperature Stability – % of initial tensile strength retained after 336 hours in air oven at 300° C, min, %	NA[A]	NA[A]	NA[A]	NA[A]	70
Tensile Strength, kPa	60	60	18	60	27
Compressive Strength, min, kPa at 25% deflection	3.4	3.4	NA[A]	NA[A]	3.4
50% Compression Deflection, min, kPa	8	8	NA[A]	NA[A]	NA[A]
Compression Set, max, %	NA[A]	NA[A]	40	40	NA[A]
Steam Aging,					
Change in Tensile Strength, max, %	25	25	NA[A]	NA[A]	25
Dimensional and weight changes, max, %	10	10	NA[A]	NA[A]	10
Corrosiveness	pass	pass	pass	pass	pass
Chemical Resistance	pass	pass	pass	pass	pass
Oxygen Index, Min. %O_2	28	28	28	28	40
Surface Burning Characteristics, 50 mm thickness[B]					
Flame Spread Index, max	10	10	15	15	10
Smoke Development, Index, max	15	15	20	20	15
Radiant Panel Surface Flammability, Flame Spread Index, max[B]	5	5	5	5	2
Vertical Burn[B,C],					
Burn Length, max, mm	NA[A]	NA[A]	50	60	NA[A]
After Flame Time, max, sec	NA[A]	NA[A]	1	1	
Total heat release (2 min), max, kW-min/m^2[B]	15	15	NA[A]	NA[A]	NA[A]
Maximum heat release rate, max, kW/m^2[B]	20	20	NA[A]	NA[A]	NA[A]
Specific Optical Smoke Density, D_m, max[B]					
non-flaming mode	5	5	5	5	5
flaming mode	10	10	10	10	5
Total Hydrogen Halide (HCl, HBr, and HF) Gases in Smoke, Flaming Exposure, max, ppm (Above background for empty chamber)[B]	10	10	10	10	10
Toxic Gas Generation: max, ppm[B]					
CO	300	300	300	300	300
HCN	5	5	5	5	5
HF	5	5	5	5	5
HCl	10	10	10	10	10
HBr	5	5	5	5	5
SO2	5	5	5	5	5
NOx	10	10	10	10	10
Acoustical Absorption Coefficient 50.8 mm thickness, min Noise Reduction Coefficient (NRC)	0.75	0.70	0.75	0.85	0.70

[A] NA = not applicable

[B] This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk under actual fire conditions.

[C] The material shall not melt, drip, or flow when tested as required.

9.1.1 Upper Temperature Limit
9.1.2 Tensile Strength
9.1.3 Compressive Strength
9.1.4 Compression Set
9.1.5 Chemical Resistance
9.1.6 Apparent Thermal Conductivity at 75° F (24° C)
9.1.7 Specific Optical Smoke Density
9.1.8 Hydrogen Halide Gases in Smoke
9.1.9 Surface Burning Characteristics
9.1.10 Radiant Panel Surface Flammability
9.1.11 Heat Release Rate
9.1.12 Sound Absorption Coefficients

10. Inspection

10.1 The following requirements are generally employed for acceptance sampling of lots or shipments of qualified polyimide foam insulation:

10.1.1 Density
10.1.2 Apparent Thermal Conductivity at 75° F (24° C)
10.1.3 Vertical burn—Type IV and V only
10.1.4 Workmanship

10.2 As agreed to by the purchaser and the manufacturer, the inspection of the material shall be made at either the point of shipment or point of delivery.

11. Test Methods

11.1 *Sample Preparation*

11.1.1 In cases where the material is cut into pipe insulation and other shapes without further treatment, slab foam test results should be representative. If other processes are used for specific applications, it is recommended that qualification testing be conducted using slab specimens, and that inspection testing should test the processed material.

11.1.2 Tests for physical and mechanical properties shall be

carried out at a temperature of 73.4 ± 3.6° F (23 ± 2° C) and at a relative humidity of 50 ± 5%. Sound absorbing, thermal, and flammability tests shall be carried out at conditions specified in the applicable test methods.

11.1.3 All test specimens for testing of physical and mechanical properties in Tables 1 and 2 shall be preconditioned by twice mechanically reducing (flexing) their thickness to a 25 percent deflection of their original thickness. In cases where a specified test method itself contains this requirement, additional flexing is not to be performed. If required, other preconditioning and physical property test limits shall be determined by agreement between the purchaser and manufacturer (Note 4).

NOTE 4—Because the flexing of polyimide foam has an impact on the measured physical properties, a standard preconditioning procedure is given. If the products performance cannot be adequately discerned using the specified preconditioning method, then a more applicable preconditioning method may be used as determined by agreement between the purchaser and manufacturer with appropriately modified physical property limits.

11.2 *Density*—Test Method D 3574, Test A.

11.3 *Apparent Thermal Conductivity*— Test Methods C 177, C 1114, and C 518 in conjunction with Practice C 1045. Test Method C 518 shall not be used at temperatures or resistances other than those in the range of the calibration. Test temperatures shall be chosen in accordance with Table 3 of Practice C 1058. Use the large temperature difference recommended in Table 3 of Practice C 1058 for temperatures between 25 and 110° F (-4 and 43° C); for mean temperatures under 25° F (-4° C) and over 110° F (43° C) use the smaller temperature difference.

11.4 *Upper Temperature Limit*—Test Method C 411 and Practice C 447 shall be used at the insulation's maximum use temperature and at maximum design thickness. No special requirements for heat-up shall be specified by the manufacturer. The foam shall not flame, glow, smolder, smoke, soften, collapse, melt or drip during hot surface exposure.

11.5 *High Temperature Stability*—Test Method D 2126 incorporating Test Method D 638. Use Test Method D 2126, with a modified test temperature of 400°F (204°C) or 572°F (300°C) as shown in Tables 1 and 2. Test before and after aging using Test Method ASTM D 638, type III specimens.

11.6 *Compressive Strength*—Test Method ASTM C 165, Procedure B.

11.7 *50% Compression Deflection*—Test Method ASTM D 3574, Test C.

11.8 *Compression Set*—Test Method ASTM D 395, test temperature is 158° F (70° C) and aging time is 22 hours.

11.9 *Steam Aging*—Test Method D 3574, Procedure J1 and Test E.

11.10 *Corrosiveness*—Test Method in C 665.

11.11 *Chemical Resistance*—Test Method D 543, practice A, procedure I at room temperature with reagents 6.3.8, 6.3.40, 6.3.46, 6.3.50, aviation turbine fuel grade JP-5 and ethylene glycol antifreeze from Table 1, and SKYDROL hydraulic fluid. Final weight and dimensions are to be determined 24 hours after removal from immersion.

11.12 *Oxygen Index*—Test Method D 2863.

11.13 *Surface Burning Characteristics*— Test Method E 84.

11.14 *Radiant Panel Surface Flammability*— Test Method D 3675.

11.15 *Vertical Burn*—Test Method FAR 25.853, Appendix F, Part 1, (a) (1) (i).

11.16 *Heat Release Rate*—Test Method E 1354 with a heat flux of 185 BTU/min-ft^2 (35 kW/m ^{2}) and using external ignition.

11.17 *Specific Optical Smoke Density*— Test Method E 662.

11.18 *Hydrogen Halides in Smoke*—Test Method E 662, with integrated sampling, and anion detection using ion chromatography, in accordance with Guide E 800.

11.19 *Toxic Gas Generation*—Boeing BMS 7239, Flaming mode.

11.20 *Sound Absorption Coefficients*— Test Method C 423, using the Type A Mounting described in Practices E 795.

12. Certification

12.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished. For the purpose of this specification, a lot consists of all material of the same type manufactured in one unchanged production run and offered for delivery at the same time.

13. Packaging and Marking

13.1 *Packaging*—Unless otherwise specified, the insulation shall be supplied in the manufacturer's standard commercial packaging. Steps should be taken to prevent damage or contamination of the foam with foreign material.

13.2 *Marking*—Unless otherwise specified, each container shall be plainly marked with the manufacturer's name, the product name, trademark, and the manufacturer's address, with dimensions and/or volumes expressed in units agreed upon by the supplier and customer.

14. Keywords

14.1 flexible cellular insulation; pipe insulation; polyimide; ship insulation; sound absorbing; thermal insulation

ANNEXES

(Mandatory Information)

SUPPLEMENTAL REQUIREMENTS TO POLYMIDE FLEXIBLE CELLULAR THERMAL AND SOUND ABSORBING INSULATION FOR U.S. NAVY SPECIFIED MARINE APPLICATIONS

A1. SCOPE

A1.1 This annex gives the requirements for fire resistant thermal and acoustic absorptive polyimide foam insulation panels and for preformed thermal insulation for use on pipes at surface temperatures from 100 to 370° F (38 to 188° C) for use in U.S. Navy shipboard applications as governed by MIL-PRF-24688A.

A2. CLASSIFICATION

A2.1 Flexible polyimide foam shall be furnished in the following Types and Classes as specified.

A2.1.1 *Type I*—Unfaced (thermal and acoustical absorptive)
A2.1.2 *Type II*—Faced
A2.1.2.1 *Type II Class 1*—Fibrous glass cloth faced (thermal)
A2.1.2.2 *Type II Class 2*—Slotted base board faced with perforated fibrous glass cloth. (acoustical absorptive)
A2.1.2.3 *Type II Class 3*—Vapor resistant film faced.
A2.1.3 *Type III*—Preformed pipe insulation.
A2.1.3.1 *Type III Class 1*—Unlagged
A2.1.3.2 *Type III Class 2*—Prelagged

A3. MATERIALS AND MANUFACTURE

A3.1 The backing foam material shall be flexible, polyimide foam generally of Type I.

A3.2 The Type II Class 1 panel or shape shall consist of the backing foam material, laminated with non-perforated fibrous glass cloth facing.

A3.3 The Type II Class 2 panel or shape shall consist of the backing foam material, laminated with perforated fibrous glass cloth facing. One face of the foam shall be slotted, 3⁄16 in. (4.76 mm) wide by 3⁄16 in. (4.76 mm) deep, ½ in. (12.7 mm) centers, in one direction only. The perforated glass cloth facing shall be bonded to the slotted side of the foam, installed so that the perforations in the cloth facing are centered over the slots in the foam. A 7⁄8in. (22 mm) border of cloth facing without perforations shall be maintained.

A3.4 The Type II Class 3 panel or shape shall consist of the backing foam material, combined with a vapor resistant film composed of reinforced aluminized polyester/aluminum foil with prime coated surface or polyester film bonded to a fiberglass scrim, (Note A3.1).

NOTE A3.1—Type II Class 3 does not apply to anti-sweat pipe covering applications.

A3.5 The Type III Class 1 material shall be flexible, polyimide foam generally of Type I and shall be formed into pipe insulation. The insulation may be split or slit lengthwise.

A3.6 The Type III Class 2 material shall consist of material conforming to Type III Class 1, laminated with lagging cloth. The lagging shall conform to the requirements of MIL-C-20079, and be free of wrinkles and other irregularities.

A3.7 Fibrous glass cloth facing shall conform to the requirements of Type I, Class 2 of MIL-C-20079, and shall be free of wrinkles and other irregularities. For Type II Class 2, the facing shall be perforated with nominal 3⁄16 in. (4.76 mm) diameter holes on ½ in. (12.7 mm) centers.

A3.8 The adhesive for bonding the facer or lagging shall conform to the fire resistance requirements of MIL-A-3316.

A3.9 Panels or shapes shall be furnished unpainted, unless otherwise specified. Painting when required shall conform to DOD-E-24607 with color as specified.

A4. PHYSICAL REQUIREMENTS

A4.1 Unfaced foam insulation is generally of Type I and shall also conform to the requirements for properties in Tables A4.1 and A4.2.

A4.1.1 *Dimensions and Tolerances*—Type I insulation sheets shall be furnished in the lengths, width and tolerances as specified in Table A4.1, when conditioned in accordance with 11.1. Other dimensions, and shapes tolerances shall be determined by agreement between the purchaser and manufacturer.

A4.1.2 *Acoustical Performance*—The unfaced foam insulation must conform to the requirements of Table A4.2, when tested in accordance with 11.20.

A4.1.3 *Quarter-scale Room Fire Test*—Flashover time, greater than 10 min. Interior temperature less than 1112° F (600° C) and doorway temperatures less than 927° F (500° C), when tested in accordance to A7.1.

A4.2 *Type II Class 1, 2, and 3 Faced Foam*

A4.2.1 *Dimensions and Tolerances*—Type II insulation panels shall be furnished in the lengths, width and tolerances as specified in Table A4.1, when tested in accordance with 11.1. Other dimensions, shapes tolerances shall be determined by agreement between the purchaser and manufacturer.

A4.2.2 *Weights and Tolerances*—The Type II panel weight shall conform to the requirements in Table A4.3, when tested in accordance with A7.2.1.

A4.2.3 *Facing Alignment*

A4.2.3.1 *Type II Class 1 and 3*—If the facing material does not cover the entire surface of the panel, the uncovered portion of the panel shall not be longer than ⅛ in. (3.175 mm) from any edge. Determination shall be in accordance with A7.3.

A4.2.3.2 *Type II Class 2*—Misalignment of the facing material over the slotted panel shall be less than 1⁄16 in. (1.588 mm) when tested in accordance with A7.3.

A4.2.4 *Painting*—Panels shall be furnished unpainted, unless otherwise specified. Painting when required shall conform to A7.4 with color as specified.

A4.2.5 *Cutability (Type II Class 1 & 2 only)*—When the panel is cut or sawed, the threads of the cloth facing across which the cut is made shall not be separated from the face over a distance of more than ⅛ in. (3.18 mm).

A4.2.6 *Puncture Resistance (Type II Class 1 only)*—The puncture resistance of the faced board shall be tested according to A7.5 and not be less than 800 ounce-force-in./in. of tear (5.65 N-m/cm of tear).

A4.2.7 *Acoustical Performance*—The insulation must conform to the requirements of Table A4.2, when tested in accordance with 11.20.

A4.2.8 *Quarter-scale Room Fire Test*—Flashover time, greater than 10 min. Interior temperature less than 1112° F (600° C) and doorway temperatures less than 927° F (500° C), when tested in accordance to A7.1.

A4.2.9 *Vapor Resistance (Type II Class 3 only)*—The vapor resistant facing and/or paint system shall have a permeance of less than 0.30 perms ($17 \times E^{-9}$ g/Pa s m) when tested in accordance to A7.6.

A4.2.10 Type II polyimide foam insulation shall also meet the requirements of Type I core foam for compressibility, corrosiveness, and thermal conductivity.

A4.3 *Type III Class 1 and Class 2 Foam*

A4.3.1 Type III pipe insulation shall be furnished in nominal lengths of 48 in. (122 cm), with a tolerance of 3⁄16 in. (4.76 mm). Type III Pipe insulation shall be furnished to fit IPS sizes of 1 to 5 in. (2.54 to 12.7 cm). The longitudinal seam shall close to within ⅛in. (0.32 cm) along the entire length of the section. The inside diameter of the insulation shall not exceed the outside diameter of the pipe by ¼ in. (0.6 cm) for nominal pipe sizes up to 4½ in. (11.43 cm) or by 5 percent on 5 in. (12.7 cm) nominal pipe size. Type III pipe insulation shall be furnished in nominal thickness of ½, ¾, 1, and 1½ in. (1.3, 1.9, 2.5, and 2.9 cm) with a tolerance of plus or minus 3⁄32 in. (2.38 mm) in thickness. Other dimensions and tolerances shall be determined by agreement between the purchaser and manufacturer.

A4.3.2 *Density*—The polyimide foam for both Type III Class 1 and Class 2 shall have a nominal density of 0.46 lb/ft^3 (7.4 kg/m^3) with a tolerance of plus or minus 20 percent when tested in accordance to A7.2.2.

A4.3.3 *Painting*—Type III Class 2 prelagged preformed pipe insulation as furnished shall conform to A7.4.

A4.3.4 *Thermal Conductivity*—Thermal conductivity for Type III shall not be greater than the values shown in Table A4.4 when tested in accordance to A7.7.

TABLE A4.1 Standard Dimensions and Tolerances Type I and Type II Class 1, 2, and 3 Polyimide Foam Slabs

	Length	Width	Thickness
Tolerance, in.	±0.25 (±6.5)	±0.25 (±6.5)	–0, +0.125 (–0, +3)
Limits, in.	36 (910)	24 (610)	0.5 (13)
	36 (910)	24 (610)	1.0 (25)
	36 (910)	24 (610)	2.0 (51)
	48 (1,220)	24 (610)	0.5 (13)
	48 (1,220)	24 (610)	1.0 (25)
	48 (1,220)	24 (610)	2.0 (51)

TABLE A4.2 Minimum Sound Absorption Coefficients Using a Type "A" Mounting Sabins/ft^2 (Metric Sabins/m^2)

	Frequency, Hz					
Nominal Thickness	125	250	500	1000	2000	4000
Type I Core Foam						
1 in. (25 mm)	0.06	0.20	0.45	0.65	0.65	0.65
2 in. (50 mm)	0.15	0.40	0.75	0.75	0.75	0.70
Type II Class 2 Faced Foam						
1 in. (25 mm)	0.07	0.25	0.70	0.80	0.75	0.70
2 in. (50 mm)	0.25	0.70	0.90	0.85	0.75	0.75

TABLE A4.3 Maximum Areal Density – Type II Class 1, 2, and 3 Faced Polymide Foam lb/ft^2(Kg/m^2)

Thickness	Type II Class 1	Type II Class 2	Type II Class 3
0.5 in. (13 mm)	0.13 (0.63)	0.12 (0.58)	0.12 (0.58)
1.0 in. (25 mm)	0.15 (0.73)	0.14 (0.68)	0.14 (0.68)
2.0 in. (50 mm)	0.19 (0.92)	0.18 (0.88)	0.18 (0.88)

TABLE A4.4 Type III Thermal Conductivity

Mean Temperature, °F (°C)	Thermal Conductivity, 1 in. thickness; Btu-in./h ft^2–°F (W/m–K)
25 (-4)	0.27 (0.039)
50 (10)	0.30 (0.043)
75 (24)	0.32 (0.046)
100 (38)	0.35 (0.050)
200 (93)	0.48 (0.069)

A4.3.5 *Flame Spread*

A4.3.5.1 The flame spread for Type III Class 1 shall not be greater than 10. The smoke developed for Type III Class 1 shall not be greater than 15.

A4.3.5.2 The flame spread for Type III Class 2 shall not be greater than 25. The smoke developed for Type III Class 2 shall not be greater than 15.

A4.3.6 *Pipe Chase Test*—Both Type III, Class 1 and Type III Class 2 shall exhibit no flame spread to the top of the vertical chase when tested to TM-232. There shall be no evidence of melting or dripping.

A5. WORKMANSHIP

Material shall be uniform in quality and condition. Material shall be clean and free from foreign materials, contaminates, and defects that will impair material use and serviceability

A6. QUALIFICATION REQUIREMENTS

A6.1 The following requirements are generally employed for initial material or product qualification with the U.S. government. When specified in the contract or order, a certificate of compliance shall be prepared. Fire, acoustic and thermal test results in the certificate of compliance shall be less than three years old. Any changes in basic ingredients or process in an U.S. Navy contract shall be promptly reported to both the contracting activity and Commander, Naval Sea Systems Command (NAVSEA).[13]

A6.1.1 Adhesive
A6.1.2 Dimensions and Tolerances
A6.1.3 Weight and Tolerances
A6.1.4 Paintability
A6.1.5 Cutability
A6.1.6 Puncture Resistance
A6.1.7 Compressibility
A6.1.8 Sound Absorption Coefficients
A6.1.9 Apparent Thermal Conductivity
A6.1.10 Flame Resistance
A6.1.11 Specific Optical Smoke Density
A6.1.12 Steam Aging
A6.1.13 Toxicity

[13] Commander, Naval Sea Systems Command, SEA 55z3, Department of the Navy, Washington, DC 20362-5101.

A7. TEST METHODS

A7.1 Determination of the flashover potential of a lining material using a quarter-scale room fire test.

A7.1.1 *Scope*

A7.1.1.1 This method describes a procedure to determine the flashover potential of materials in a room when subjected to a fire exposure. The method described will yield a time from the introduction of the fire exposure until the moment of flashover. The information contained herein is intended for compliance.

A7.1.1.2 This method is used to measure and describe the response of materials, products or assemblies to heat and flame under controlled laboratory conditions, but does not incorporate all factors required for fire hazard or fire risk assessment of materials, products, or assemblies under actual fire conditions.

A7.1.2 *Significance and Use*—In the interest of reducing both set-up time and cost associated with fire testing in a full size room (defined as a 10 ft (3.05 m) long by 10 ft (3.05 m) wide by 8 ft (2.44 m) high room having a 30 in. (76.2 cm) wide by 80 in. (203 cm) high doorway), a one-quarter scale room fire test was devised to predict flashover potential of lining materials.

A7.1.3 *Equipment*

A7.1.3.1 The quarter-scale room shall be constructed from a suitable insulation board and shall form an airtight box having a ceiling and four sides. The box shall sit on a floor fabricated from the same material. The interior dimensions of the fully lined quarterscale room shall be 30 in. (76.2 cm) long by 30 in. (76.2 cm) wide by 24 in. (61 cm) high. The doorway is located at the center of one wall and shall be 19.5 in. (49.5 cm) wide and 17 in. (43.2 cm) high to secure proper ventilation and fire development. The height between the finished ceiling and top of the doorway shall be 7 in. (17.8 cm). The floor of the model room shall extend at least 12 in. (30.5 cm) outside the doorway. The box shall be removable to allow for application of ceiling and wall covering. The entire base of the box in contact with the floor shall be airtight.

A7.1.3.2 A porous plate diffusion flame burner shall be used

as the fire source. The burner shall be 3.5 in. (8.9 cm) long by 3.5 in. (8.9 cm) wide by 3 in. (7.6 cm) high, consisting of horizontal porous plate area of 3 by 3 in. (7.6 by 7.6 cm) with 0.25 in. (0.64 cm) wide steel plate perimeter and steel plate sides and bottom.

A7.1.3.3 Four 10 mil chromel-alumel thermocouples shall be used, 1 in. (2.5 cm) and 3 in. (7.6 cm) below the center of the overhead and 1 in. (2.5 cm) and 2 in. (5.1 cm) below the top of the doorway.

A7.1.4 *Procedure*

A7.1.4.1 The test material shall fully line the walls and ceiling.

A7.1.4.2 Prior to testing, the fully lined test room shall be conditioned for at least 24 hours at a relative humidity between 20 and 60 percent, and a temperature of 73 ± 9° F (23 ± 5° C).

A7.1.4.3 The fire source shall be positioned on the floor snugly against one rear corner of the test room. A flow rate of 0.32 ft ^{3}/min (0.15 1/sec) methane shall be used to produce a constant heat input of approximately 320 Btu (338 kJ) for the duration of the test.

A7.1.4.4 The test data from the four thermocouples shall be recorded as a continuous function of time.

A7.1.4.5 The primary data generated by this test will be the time to flashover, if it occurs, and the maximum temperature if flashover is not reached. Flashover is characterized by thermal flux levels equal to or greater than 12.9 W/in.^{2} (2 W/cm^2) at the floor level. This corresponds to interior temperatures of 1,112° F (600° C) and higher, and doorway temperatures of 932° F (500° C) and higher. For this test purpose, flashover is defined as the fire condition when one of the interior thermocouple measurements reaches 1,112° F (600° C) or one of the doorway measurements reaches 932° F (500° C), whichever occurs first.

A7.1.4.6 A color photographic record shall be made of the material before the test, at the point of maximum involvement and after the fire has been extinguished.

A7.1.5 *Precision and Bias*—The precision of this test method is not known because inter-laboratory data are not available. This method may not be suitable for use in specifications or in case of disputed results as long as these data are not available.

A7.2 *Weight and Tolerances*

A7.2.1 *Type I and II*—Weight and tolerances shall be determined by Test Method D 3574 Test A.

A7.2.2 *Type III*—Density shall be determined in accordance with Test Method C 302.

A7.3 *Facing Alignment*—Face alignment shall be tested by direct measurement using a steel rule with at least 1⁄16 in. (1.5 mm) graduations.

A7.4 *Paintability*—One coat of latex emulsion flat primer and one coat of fire retardant paint conforming to DOD-E-24607 shall be applied to the cloth surface of the Type II Class 1 or Type III Class 2 insulation. The paint shall dry to a uniform smooth coat, which shall have a flat to semigloss appearance and exhibit no shiners or flashes when viewed under ordinary conditions of illumination.

A7.5 *Puncture Resistance*—Puncture resistance shall be tested by Tappi T 803, except the 24 by 18 in. (61 by 45.7 cm) test specimen shall be placed with the cloth faced down between the clamping plates. The loose sleeve shall be placed against the base of the puncture point and the pointer shall be set about 1 in. (2.5 cm) above the expected reading. The pendulum shall be raised to the horizontal position. The pendulum shall be released by pushing the latch handle to the left. The reading on the proper scale shall be noted after the pendulum has completed its swing. Two determinations shall be made in the warp direction and two in the filling direction of the cloth on each specimen.

A7.6 Films for use in Type II Class 3 panels or shapes shall be tested by E 96.

A7.7 Pipe insulation shall be tested in accordance to ASTM C 335.

APPENDIX

(Nonmandatory Information)

X1. RATIONALE

This specification covers the composition and physical properties of lightweight, flexible, cellular polyimide. Annex A1 is intended to incorporate MIL-PRF-24688 (Insulation, Thermal and Acoustic Absorptive) into an ASTM commercial specification. The foam is used as thermal and sound absorbing insulations for a wide variety of industrial and commercial applications. U.S. Navy and marine applications are one of the major markets. Several different polyimide foam products with different requirements are sold into numerous specialty markets where polyimide foam has proven performance.